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RADIATION PROTECTION PROGRAM FOR LANDFILL WORKERS

13-Mile Landfill, Williston, ND

Revision 7.1



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1. Purpose

This purpose of this Radiation Protection Program is to establish minimum health, safety, and training requirements for SECURE Energy personnel at our U.S. Landfill(s) where the management and disposal of E & P waste streams may include Technologically Enhanced Naturally Occurring Radioactive Material (TENORM). Ensuring that all reasonable precautions are taken to protect workers who may be required to work with radioactive materials including NORM and TENORM is consistent with our corporate objectives to minimize exposure levels to employees so that they are as low as reasonably achievable (ALARA).

This practice provides guidelines to ensure employees and workers are fully knowledgeable of the correct procedures to be followed for worker protection, that the environment is protected from potential contamination, and that radiologically-impacted materials are managed in accordance with all applicable radiation control regulations. It is intended to augment published operations plans and procedures, not replace them.

2. Scope

This practice applies to all SECURE Energy employees, contract employees, contractors and other visiting personnel conducting work activities on SECURE Energy premises and worksites.

This Radiation Protection Program follows the Conference of Radiation Control Program Directors (CRCPD) Suggested State Regulations for Control of Radiation (SSRCR): Part N "Regulation and Licensing of Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)" and sets the minimum standards for radioactive materials management including the following key elements:

- Management control over work practices including supervisory requirements to ensure Radiation Protection (RP) procedures are developed and implemented;
- Personnel qualifications and training;
- Control of occupational and public exposure to radiation;
- External gamma radiation monitoring and protection;
- Contamination monitoring and control;
- Environmental controls; and
- Waste management controls.

In conjunction, the Radiation Protection Program outlines the appropriate recordkeeping requirements for:

- Dose Assessments;
- Training records;
- Screening, contamination and radiation surveys;
- Environmental monitoring; and
- Waste management tracking, transport and manifest documentation.

3. Administration

The SECURE management team administers the Radiation Protection Program to ensure that:

- Radiation surveys are prioritized and conducted as required to identify potential radiation management issues;
- SECURE Standard Operating Procedures (SOPs) for the management of radioactive materials are implemented;
- The Radiation Protection Program is implemented in each operating area where radioactive materials have been identified during screening surveys;
- All personnel (employees or subcontractors) required to work or potentially exposed to radioactive materials understand the corporate requirements and have received appropriate training in radiation protection;
- Implement policies and requirements to maintain employee exposure As Low As Reasonably Achievable (ALARA).
- Support resources needed to oversee and control all radiation safety and radioactive material waste management requirements are well-defined. Specifically,
 - **Landfill Managers**, including the **Facility Manager and Facility Lead**, will be fully responsible for proper implementation of SOPs at his/her designated facility (where radioactive materials exist). This includes the proper use of personal protective equipment (PPE), equipment used for sample analysis, and on-site waste management including proper use of survey instruments, proper documentation and logistics surrounding TENORM-impacted waste streams.
 - **Landfill Staff**, including the **Lead Operator and Operators, as well as the Lead Administrator and Scale Desk Administrator**, will follow SOPs in routine screening of waste and subsequent waste management based on test results of (potentially) TENORM-impacted waste streams. This will include proper documentation of TENORM-impacted waste streams and appropriate utilization of PPE. The landfill
 - The **Corporate Radiation Safety Officer (RSO)** will have broad oversight over radioactive materials license compliance, regulatory affairs, rad training programs, the dosimetry program, and the development/maintenance of SOPs including this radiation protection program.

Organization Structure

13-Mile Landfill's organizational structure is designed to maximize accountability and efficiency through clear functional and reporting responsibilities combined with each persons' unique skills and giftedness.

The chain of command is as follows for day-to-day operations:

- Executive Vice President
- Vice President, Operations & Sales
- General Manager, U.S. Operations/U.S. Board Member
- Facility Manager
- Lead Administrator & Lead Operator (same level but different functions)
- Operator & Scale Desk Administrator (same level but different functions)

Additional support is provided by other key personnel including:

- Corporate RSO
- Environmental & Regulatory Specialist

4. Training

Awareness and Technician Training are a major part of our radiation protection program and no facility employee is exempt from its requirements.

All new landfill employees must receive safety orientation and **TENORM Awareness Training** at the beginning of their first day of work at the Landfill.

TENORM Awareness Training may be delivered by a Facility Manager or Facility Lead that has completed 8-hour TENORM Technician Training. The Facility Manager and Facility Lead are required to use the Corporate RSO-provided training that includes the following topics:

- Relative risk and context associated with the levels of radioactivity typically found in on-site waste streams
- Personal Protect Equipment (PPE) requirements as a result of presence of TENORM, site conditions, and work responsibilities
- Overview of the company's dosimetry program
- Overview of waste streams that potentially include TENORM
- Personal decontamination procedures and precautions
- Overview of the State of North Dakota's rules, regulations, and screening and load rejection criteria
- Survey instrument operation

Landfill employees who have any responsibility for surveying or sampling waste, or who makes determinations as to the acceptance or rejection of TENORM waste, or whose job functions may include waste management and/or direct contact with TENORM-impacted waste streams must attend and pass SECURE Energy's **TENORM Technician (8-hour) Training for Landfill Employees** (see course content on the following page).

This includes job titles such as Lead Operator, Operators, Scale Administrators, HSE and Compliance personnel, Facility Leads and Facility Managers (i.e., virtually all landfill employees). An employee who acts purely in a billing or administrative capacity and does not work outside of the building, come into direct or indirect contact with any waste streams, and does not make waste acceptance or rejection decisions, may be exempted from TENORM Technician Training and can simply take TENORM Awareness Training.

If a specific employee has previously taken and passed SECURE Energy's TENORM Surveyor Training, they may take TENORM Landfill Operations Refresher Training to meet this requirement.

TENORM Landfill Operations Refresher Training will be required annually and includes the following topics:

- Standard Operating Procedures for screening and sampling to determine waste acceptance and rejection of TENORM waste;
- Daily cover requirements;
- Health and Safety protocol as outlined in this Radiation Protection Program for TENORM Landfill Employees;
- State of North Dakota's rules and regulations including the maximum annual TENORM intake limit; and
- TENORM load acceptance/rejection processes, procedures, and required documentation.

TENORM Technician (8-hour) Training for Landfill Employees is required for most landfill employees (titles and job functions above). It includes the following topics:

- Sources of TENORM radioactive contamination;
- Hazards of radiation and the necessary controls to mitigate;
- The risks associated with radiation to which the worker may be exposed in the course of his or her work;
- Comparisons of other radiation sources personnel are exposed to everyday;
- Safe work procedures including selection of TENORM specific Personal Protective Equipment (PPE), respiratory protection requirements and use of radioactive contamination control zones and personnel decontamination procedures;
- Emergency Response;
- Radiation fundamentals;
- Survey instrument training including actual surveys of TENORM demonstrating techniques and appropriate probe selection;
- TENORM regulatory requirements including the applicable radiation dose limits for incidentally and occupationally exposed workers;
- Survey documentation;
- Representative Sampling;
- Laboratory results analysis;
- Area posting and signage requirements;
- Radiation monitoring procedures before working with TENORM-impacted equipment or waste including managing control areas and fixed and removable contamination surveys;
- Waste acceptance and rejection SOPs relative to TENORM-impacted waste streams; and
- Daily cover requirements and other operational impacts of TENORM waste management.

The **Lead Operator and Facility Manager**, as well as any other landfill employees who are given additional responsibilities as they grow in their careers, will require the following additional training:

- Representative waste sampling techniques;
- Daily cover requirements and related management of operations to ensure compliance with state rules/regulations;
- TENORM waste volume tracking oversight (monitoring for 25,000-ton annual limit and 3,000-ton monthly limit);
- “Free release” procedures and documentation requirements for any equipment used in managing TENORM waste streams that has either been rented (which will be returned to the vendor) or is to be sold or disposed of;
- 40-hour RSO training (Facility Manager only) by an independent, ND DEQ-approved training company.

The **Corporate Radiation Safety Officer** must have the following training and skills:

- 40-hour RSO training and certification by an independent, ND DEQ-approved training company that includes:
 - Workplace inspections and audits;
 - Biological and health effects of radiation exposure;
 - Radiation detection, instrumentation and calibration;
 - Regulatory agencies and standard-setting organizations;
 - Free release processes and documentation; and
 - Licensing of nuclear substances and radiation devices.
- Waste management, handling and storage procedures;
- Survey and sampling plans;
- Record keeping requirements including documentation and review of employee dose;
- Signage, posting and labeling regarding the presence of TENORM;
- Shipping and transportation of radioactive materials;
- Disposal options and management of TENORM-impacted waste and equipment;
- Air sampling;
- Liability minimization and financial assurance management;
- Detailed knowledge and practical abilities necessary to implement and monitor a Radiation Protection Program;
- A thorough review and understanding of all applicable federal, state, local, and company regulatory requirements; and
- Extensive practical experience with TENORM surveying, worker radiation protection, and risk communication.

5. TENORM Formation

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) has been recognized as a potential hazard in industries that produce our natural resources. These include oil and gas, mining, refractory brick and ceramics manufacture, fertilizer, water treatment, and power generation industries.

The origin of TENORM in the oil and gas industry is primarily through the concentration of Radium (Ra-226 or Ra-228) associated with produced water production and Lead (Pb-210) associated with natural gas production. These radionuclides are daughters of uranium and thorium which are incorporated in the Earth's crust and form part of the earth's natural background radiation.

Generally, NORM (naturally occurring radioactive materials) exists in low concentrations in rock formations and pose little radiological concern. However, as part of industrial activities such as oil and gas production, NORM can be transported to surface and concentrated to levels that may pose a hazard to human health and the environment (TENORM). For example, barium or calcium scale precipitated from oil recovery brine may concentrate radium at much greater concentrations than the original produced water source itself.

While there is potential to exceed allowable external radiation doses as a result of larger accumulated volumes and concentration of TENORM, in most cases, the radiological concern to workers is from the inhalation or ingestion of TENORM materials.

TENORM hazards are easily mitigated and controlled by implementing safe work procedures. As a result, special precautions are needed for handling, storing, transporting, and disposal of material, by-products, end-products or process equipment containing TENORM.

6. Radiation Hazards

Two types of radiation hazards may be encountered: external hazards and internal hazards. The difference is whether the hazard is outside the body (an external hazard) or inside the body as the result of inhalation or ingestion of radioactive material (an internal hazard).

6.1 External Radiation Hazard

External radiation exposure occurs when personnel are exposed to ionizing radiation from sources outside the body. Typically, external TENORM radiation hazards in the oil and gas industry are extremely low. External radiation doses can be maintained ALARA by applying the radiation control principles of time, distance and shielding.

Operations will be conducted so that individual members of the public and incidental workers will not exceed 100 mrem/yr (1 mSv/yr) Total Effective Dose Equivalent (TEDE) annually. SECURE employees will be monitored for external radiation dose by use of dosimetry or direct measurement to verify that the TEDE is not exceeded.

6.2 Internal Radiation Hazard

Internal radiation exposure occurs when TENORM gets into the body and is of far greater concern than external radiation exposure. Some radioactive isotopes may not be eliminated from the body for several decades and a very large cumulative dose may build up as a result.

Internal contamination is prevented by avoiding the inhalation or ingestion of radioactive materials.

- Inhalation is a common route of entry. All feasible measures must be taken to prevent radioactive particles from becoming airborne and to maintain internal doses ALARA. Industrial operations, such as welding, grinding or cutting can create an inhalation hazard. Engineering controls including using water to prevent materials becoming airborne, using engineered ventilation controls, utilization of HEPA air filtration units, good housekeeping, and closure of emission points. If the dust cannot be controlled through these measures, workers must use respiratory protection. See Section 8.1 for personal protective equipment guidelines.
- Ingestion of TENORM may occur when contaminants are deposited on personnel, clothing, PPE, or equipment and then transferred into the body. Engineering and administrative controls shall be implemented to maintain internal ingestion ALARA. See Section 8.1 for personal protective equipment and other risk mitigation guidance.

7. Worker Protection & Exposure Control

7.1 ALARA Principle

The basic philosophy of worker protection from all radioactive materials, including TENORM, is to maintain all exposures ALARA. In other words, if it is practical to avoid unnecessary exposures, that is the preferred objective.

In addition to the principle of ALARA, maximum TENORM exposure or dose limits to workers and members of the public have been developed as outlined in section 7.2. The maximum allowable dose limit for members of the public and incidentally exposed workers is 100 mrem/yr (1mSv/yr) TEDE.

7.2 Radiation Exposure Limits

Doses to members of the public, and workers must be estimated by conducting a radiation survey of the workplace/worksites or by dosimetry. The radiation surveys should include evaluations of both gamma dose-rates. Occupationally exposed workers, or “radiation workers” are considered to be those who work in an environment with work related radiation exposures. Properly trained radiation workers may receive doses in excess of 100 mrem/yr (1 mSv/yr). Any dose levels above 25 mrem/quarter (0.25 mSv/qtr) will be assessed and the worker’s activities, behavior, and dose rate scrutinized more closely.

Occupation Health and Safety Regulations and the SECURE Radioactive Materials License requires monitoring and development and implementation of a Radiation Control Plan if workers are potentially subject to elevated radiation levels. Estimates of the effective dose to workers and the public must consider the following exposure pathways:

- External exposure.
- Ingestion of TENORM-containing materials.
- Inhalation of TENORM-containing dust.
- Inhalation of radon gas and its radioactive decay products.

Table 1 outlines radiation exposure limits for different types of workers and the public. These limits are in addition to natural background exposures and include both internal exposures and external exposure pathways.

Incidentally exposed workers are employees whose regular duties do not include exposure to TENORM sources of radiation. They are considered members of the public who work in an occupational exposure environment.

The occupational dose to individual adults shall be controlled to the following dose limits:

- i. An annual limit, which is the more limiting of:
 - (1) The total effective dose equivalent being equal to 5 rem (0.05 Sievert); or
 - (2) The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem (0.5 Sievert).
- ii. The annual limits to the lens of the eye, to the skin, and to the extremities which are:
 - (1) A lens dose equivalent of 15 rem (0.15 Sievert);
 - (2) A shallow dose equivalent of 50 rem (0.5 Sievert) to the skin or to any Extremity.

Table 1 Radiation Dose Limits

<i>Affected Group</i>	<i>Annual Limit</i>
Occupationally Exposed Workers & Adults	5 rem (50 mSv)
Incidentally Exposed Workers & General Public	100 mrem (1 mSv)

7.3 Derived Working Limits (DWLs)

Derived Working Limits (DWLs) have been determined from the annual radiation dose limits to assist in dose assessments. The DWL's provide an estimate of dose that can be directly measured in the workplace. Table 2 outlines the incremental gamma radiation dose rate in the workplace for each classification group and the steps required to maintain a high level of health and safety for the workers and the public.

Table 2 Derived Working Limits – Gamma Dose Rate Thresholds

TENORM CLASSIFICATION	THRESHOLD DOSE mrem/a	DERIVED WORKING LIMIT - (above background)	THRESHOLD REQUIREMENTS
Investigation Threshold	≤ 100 mrem/a (≤ 1.0 mSv/a)	≤ 50 μ rem/hr (≤ 500 nSv/hr) for 2,000 exposure hours per annum	<ul style="list-style-type: none"> - Public and worker access unrestricted. - Workers follow TENORM safe work guidance in Section 8.1. - Workers follow TENORM waste handling, shipping and material management procedures.
TENORM Management Threshold	> 100 mrem/a to 2000 mrem/a (> 1.0 mSv/a to 20 mSv/a)	> 50 μ rem/hr to 250 μ rem/hr (> 500 nSv/hr to 2500 nSv/hr) for 2,000 exposure hours per annum	<ul style="list-style-type: none"> - Public access and incidentally exposed worker access restricted. - Workers follow TENORM safe work guidance in Section 8.1. - Workers follow TENORM waste handling, shipping and material management procedures. - Report levels to employee and look for reasonable mitigation measures to further limit dose and maintain ALARA.
Radiation Protection Management Threshold	> 2000 mrem/a (> 20 mSv/a)	> 250 μ rem/hr ($> 2,500$ nSv/hr) for 2,000 exposure hours per annum	<ul style="list-style-type: none"> - Public access and incidentally exposed worker access restricted. - Workers follow TENORM safe work guidance in Section 8.1. - Workers follow TENORM waste handling, shipping and material management procedures. - Report levels to employee and look for reasonable mitigation measures to further limit dose and maintain ALARA. - Ensure that workers do not exceed a five-year average occupational effective dose of 2000 mrem/a (20 mSv/a)

7.4 Action Levels

In order to ensure on-going monitoring of doses and assurance that ALARA is being maintained, personal dosimetry badges (exchanged and reviewed quarterly by the Corporate RSO) will be issued to each Landfill employee, providing empirical data to compare with the thresholds defined in the Derived Working Limits (Table 2 above) to determine level of appropriate actions required to mitigate risk.

Perimeter dosimetry (area) badges will provide confirmation that the public dose limits have not been exceeded (see section 7.5.2).

7.5 Air Sampling

Air sampling for longer lived TENORM radionuclides typically being disposed in the landfill, e.g., Uranium^{Nat}, Radium-226 + Radium-228 and Lead-210 will be performed as required by the ND DEQ (and described in the *Air Sampling Procedures* section below) to empirically establish the actual levels of radioactivity in the air at the facility. Grab samples will be collected using a high-volume air sampler and initially analyzed for gross alpha activity. Count time and collection air volume will be sufficient to achieve $\leq 10\%$ the derived air concentration (DAC) using the most restrictive value for the expected radionuclide(s) as established by the United States Nuclear Regulatory Commission (USNRC) in 10CFR20, Appendix B, unless product characteristics are known such that a specific solubility class or absorption type (ICRP 30 solubility class - D,W,Y ; ICRP 71 absorption type - F,M,S) can be assigned. Should gross alpha activity exceed 10% of the most restrictive DAC, the air filter will be further analyzed to determine isotopic composition.

Following isotopic analysis, should levels exceed 0.10 DAC (Derived Air Concentration) for any single nuclide, the Corporate RSO shall - consistent with maintaining the total effective dose equivalent ALARA - increase monitoring and limit intakes by one or more of the following means:

- (1) Control and/or limit employee access;
- (2) Limit exposure times;
- (3) Use personal breathing zone (“lapel”) air samplers to more accurately assess air concentrations in worker breathing zones and to estimate worker intakes and dose;
- (4) Use additional cover material; and
- (5) Use sprayed fresh water for dust control.

Although it is expected that worker exposure from radon and progeny will be within the range of existing background, nonetheless, Track Etch radon detectors will be used in the vicinity of landfill to document this. The dose from radon comes primarily from its short-lived particulate progeny, which attach to lung surfaces depositing alpha energy, not from the inert gas itself, most of which is quickly exhaled. The importance of this dosimetric relationship between radon gas and its progeny has been well documented early in the history of uranium mining. That is, without time for ingrowth of the radon progeny, inhalation of ^{222}Rn by itself results in little dose. In out-of-doors environments, "fresh" radon released from the soil disperses quickly with the wind and contributes little to dose.

Locations for radon monitoring will be selected based on consideration of maximum worker occupancy as well as perimeter locations to assess potential releases to unrestricted areas. The monitoring equipment will be placed at the selected east, west, north, and south perimeter locations.

7.5.1 Air Sampling - Workers

The Corporate RSO may elect to conduct random air sampling to simply verify that workers are receiving little to no exposure as a result of inhalation. If any air sampling does take place, documentation and records will be properly retained. For any air sampling and associated assessment of airborne exposure to workers, the applicable recommendations of US NRC Regulatory Guide 8.25, "Air Sampling in the Workplace" will be used for guidance as well as SOP # 1 (attached).

7.5.2 Air Sampling to Assess Releases to Unrestricted (Public) Areas

Continuous air monitoring for long lived particulate radionuclides will be conducted as long as required by the DEQ with samples being collected from all 4 sides (north, south, east, and west perimeters) via air sampling equipment designed for environmental long-term use.

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Sampling will be conducted prior to receipt of any TENORM material (and the beginning of continuous monitoring) to establish a baseline (background levels).

For the continuous monitoring, a filter will be collected from each air-sampling unit weekly to minimize the risk of dust "loading." The air filter samples will be removed and properly labeled, before being sent to the approved laboratory for approval. Then the filters from each location will be analyzed. The objective is to verify the absence of significant, incremental impact to the environment, members of the public, or workers through the strategic placement of monitors all four sides of the landfill, giving consideration as to where people are likely to have the most enduring presence.

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The filters will be analyzed by a radiochemical laboratory to determine the levels of any radioactivity. Laboratory-reported specific radionuclide activities for the filter set are divided by the total volume of air that passed through the air filters over the sampling period to determine the average air concentrations for each radionuclide for the period sampled at that specific sampling location.

During operations, should airborne concentrations for any nuclide exceed 50% of the annual unrestricted area concentration specified in 10 CFR 20, Appendix B, Table 2, Column 2, the RSO will investigate and evaluate causes and corrective actions as may be necessary, including adjustments to engineering or administrative controls in order to maintain concentrations in unrestricted areas ALARA. If such an evaluation is necessary, it will be documented.

8. Worker Dose Mitigation

The mechanisms for worker exposure are via external gamma radiation, inhalation of radioactive dusts and/or radon and its progeny during work activities and, to a lesser extent, inadvertent ingestion of TENORM. Methods to be used to assess and assign dose to workers (TEDE and/or CEDE) at the project are described in SOP #2. The following procedures will be implemented to mitigate the potential for worker exposure.

- To the extent practical, process or other engineering controls, such as worker rotation, time limitations, dust suppression, decontamination or ventilation, will be used to control the concentrations of radioactive material in air.
- When it is not practical to apply process or other engineering controls to control the concentrations of radioactive material in air to concentrations that could result in a worker receiving > 10 TEDE in a week, a control area must be created in the immediate area where work on TENORM-contaminated materials is performed. Signs shall be erected around the perimeter of the contaminated work area to notify personnel of the TENORM hazard and to restrict access to unauthorized personnel.
- All personnel who may come into direct contact with TENORM contamination must be advised of the hazards associated with the TENORM-contaminated materials and wear appropriate protective personal equipment (PPE) as defined below and in Section 8.1.
 - Approved fire-resistant (FR) safety coveralls or other approved FR clothing as may be approved by the Facility Manager; and
 - Approved safety glasses; and
 - Steel-toed boots (in good condition); and
 - Disposable gloves (or gloves that will be thrown away) in good condition without holes or tears; and
 - A ½ mask may be used *if* there is moderate increased risk due to wind and dry, dusty conditions to mitigate the risks of particulate inhalation (or a fit-tested individual with medical approval for respiratory use may be required at the direction of the RSO or Landfill Manager if extreme conditions exist and extra precaution is dictated); and
 - Tyvek® suits *only if* there will be extensive direct contact with TENORM-impacted material, especially if the material is wet and/or contamination will be easily absorbed by or transferred to clothing.

- Where possible, keep material damp but not wet, to prevent dust generation while minimizing the volume of contaminated wastewater.
- Eating, drinking, chewing, and smoking is not permitted within or in close proximity to a landfill cell where TENORM is being stored or disposed of.
- Any landfill employee, contractor, or visitor that has been directly exposed to the TENORM controlled work area should be surveyed/"frisked" out upon leaving the work area to verify the absence of TENORM contamination. Detectable contamination in excess of 2x background levels will be removed as described in Section 8.3. All personnel shall observe good personal hygiene and wash face and hands to prevent any possible ingestion of TENORM-contaminated material.

8.1 Personal Protective Equipment (PPE)

During routine operations where TENORM-impacted material may be present, disposable gloves and safety glasses must be worn in addition to the normal requirement for fire-resistant clothing and steel-toed boots. Tyvek® suits may be used where wet material or excessive direct contact makes disposable attire prudent.

Additionally, as discussed in Section 7.5, the RSO may need to institute a formal respiratory protection program using guidance in, e.g., US NRC Regulatory Guide 8.15. It is not anticipated that this level of protection will be necessary. However, if a formal respiratory protection program were implemented for any reason, landfill workers with responsibilities out-of-doors would be fit tested and equipped with the appropriate masks.

TENORM concentrations can present both an external and internal exposure hazard. Due to the type of ionizing radiation involved with oil and gas production TENORM, inhalation is the major concern for exposure.

Wear protective boots, gloves (and Tyvek® suits, as appropriate) to minimize risks from direct contact with TENORM contaminated material or equipment. Whenever possible, use easily washable or disposable PPE.

Modifications to the PPE requirements may be made by the Landfill Manager, sufficiently trained Landfill Lead, or Corporate RSO, depending on local conditions.

8.2 Contamination Control Areas

Of primary importance in the prevention and spread of contamination is the identification and maintenance of defined, secure working boundaries or zones. Work involving the handling of TENORM shall be confined to areas designated as Exclusion Zones as determined by the Landfill Manager, Lead Operator, or Corporate RSO. These controlled areas will be delineated and access to and egress from the areas will be restricted and controlled.

The Landfill Manager and/or Lead Operator will ensure that unauthorized access to the area is prevented and shall control traffic by means of prescribed access points and ensure all employees working in an Exclusion Zone has received appropriate instructions about the nature of the radiation hazards in the area.

Landfill employees leaving the Exclusion Zone will be monitored for contamination. Equipment within the Exclusion Zone will be wiped down prior to leaving the area. Equipment will subsequently be monitored by a Landfill employee (TENORM Technician trained) to ensure that there is no TENORM radioactivity greater than 2x local background.

PPE must be removed at the Exclusion Zone boundary if it is found to have any surface contamination on it above background levels. If contamination is below 2x background and loose contamination is removed, it can then be bagged or otherwise contained and disposed of in the active cell as regular oilfield waste.

If the PPE is found to be greater than 2x background, then it must be properly contained in a labeled drum or container for disposal at a licensed disposal facility. Any equipment that is used in TENORM-impacted areas regardless of duration must be decontaminated and surveyed for free release prior to removal from the Exclusion Zone. If the equipment will leave the facility, whether for repair/maintenance, transfer, or sale, the survey of the equipment must be sent to the Corporate RSO for review. The RSO will then review the survey before sending it to ND DEQ Radiation Control personnel for approval of the movement, sale, or transfer. Records of survey results of contamination monitoring of released equipment and the Exclusion Zone shall be kept by the Landfill Manager as long as is required by the ND DEQ.

8.3 Personal Hygiene

Good housekeeping and good personal hygiene are basic expectations of all landfill employees. Eating, drinking, and smoking in workplace areas where contamination may be present is not allowed.

Where direct contact with TENORM-impacted material has occurred, the following procedure may be used for decontamination of skin. Continue with each step of the procedure until no contamination is detected:

- Monitor skin carefully to determine contamination level and location;
- Wash with tepid soap and water. Leave soap lather on for two to three minutes before rinsing (waterless hand cleaner has proved to be extremely effective at removing loose contamination from the skin);
- Re-monitor; do not use harsh cleansers or abrasive techniques for washing.
- Wash skin with a mild detergent. Scrub carefully with a soft bristly brush, soap, and water. Stop if skin reddens. Re-monitor.
- If contamination persists, consult the RSO immediately.
- The removed material (along with any wash water) will be placed into a container and will be labeled, inventoried and deposited into the onsite TENORM waste storage area.
- The normal PPE required during active cleanup work will include disposable clothing such as Tyvek® suits and gloves. Disposable clothing will be removed prior to leaving the Exclusion Zone and bagged for disposal in the closest onsite waste storage area.

8.4 Personnel Dosimetry Requirements

A NVLAP-approved dosimetry service will be used to measure the radiation doses to occupationally exposed workers.

A control dosimeter(s) will be kept in an area at background radiation levels and not the area of active work. All workers engaged in TENORM activities will be supplied with a personal dosimeter clearly identified with each individual's name, which they will be required to wear daily while at the jobsite. Workers must pick up their dosimeters from the designated location at Landfill's administration building at the beginning of each day and wear it for their entire shift.

At the end of each day, workers must return their badges to the designated location. Visitors will not be required to wear badges (unless required by the Corporate RSO) due to the low levels accepted at the Landfill. The reporting period for the dosimeters is quarterly.

Each quarter, the dosimeters will be replaced with new ones and those which have been worn, the controls, and any unused dosimeters will be returned by management to the licensed dosimetry company for measurement. Workers will be notified of their accumulated doses once the results have been received and reviewed - these are typically posted in a readily accessible area to all workers, such as the lunchroom. Workers are not to share or trade dosimeters.

Workers will be provided with appropriate dosimeters at the beginning of each day. It is the responsibility of the workers to:

- Ensure the dosimeter is worn on their upper or mid-portion of the body at all times while working.
- Ensure dosimeter s are returned to the proper rack at the end of each day or prior to leaving the site.

A lost or missing dosimeter is to be reported immediately to the Landfill Manager and Corporate RSO and a replacement will be provided as quickly as possible.

The Corporate RSO will investigate immediately the cause of any personnel exposure that is anomalous, or which exceeds the applicable administrative control level (see SOP #2 – Dose Evaluations, for methods of dose assessment and assignment to be used). If warranted, the Corporate RSO will take corrective actions to ensure that unnecessary exposures are halted and recurrence is prevented. A report of each investigation and the actions taken, if any, will be recorded and maintained for inspection purposes.

If an action limit is exceeded, the Corporate RSO will:

- conduct an investigation to establish the cause for reaching the action level;
- identify and take action to restore the effectiveness of the implemented radiation protection program; and
- notify senior management.

If appropriate, an ALARA review will be performed. See Appendix A, which delineates the process.

8.5 Declaration of Pregnancy and Notification to Female Worker

Every female landfill employee will be informed, in writing of:

- The risks associated with the exposure of embryos/unborn babies to radiation and the risks to breast fed infants from the intake of radioactive substances/material;
- The importance of informing the licensee, as soon as feasible, in writing, that the female worker is pregnant or breastfeeding;
- The rights of a pregnant worker and the rights of a breastfeeding worker; and
- The applicable effective dose regulatory dose limits for pregnant workers.

This notification will be documented via Appendix B, Notification to Female Workers. A copy of this written acknowledgement from each female worker will be kept in the records by the RSO.

Should a female worker inform the RSO in writing of a pregnancy (see Appendix C), her work will be assessed by the RSO. Should her work require her to work near radioactive material, a fetal dosimeter will be issued, and her radiation dose will be restricted to an effective dose (measured by whole body dosimetry badge) of 500 mrem for the balance of the pregnancy, as measured by their dosimetry. If necessary and justified (as assessed by the RSO in consultation with the worker), the worker's job may be modified to minimize her radiation exposure for the duration of the pregnancy.

Similarly, should a female worker inform the RSO in writing that she is breastfeeding an infant, her work will be assessed by the RSO. If necessary and justified (as assessed by the RSO in consultation with the worker), the worker's job may be modified to minimize her risk of intake of radioactive material for the duration of the breastfeeding. Modification of a worker's duties due to breastfeeding is not expected to be required, as the as intake of any radioactive material is highly unlikely.

9. Radiation Monitoring Equipment

Personal dosimetry (badges) will be issued to all operators/trained TENORM technicians at the landfill and badges will be exchanged on a quarterly basis. Area badges will also be posted at 4 locations (N/S/E/W) along the perimeter of the landfill to measure the dose to the public at the facility boundaries. The dosimetry program and quarterly dose review will be monitored by the Corporate Radiation Safety Officer.

Gamma survey meters, typically outfitted with NaI scintillation probes, will be used for monitoring gamma radiation fields. The exact type and make will be determined by the Corporate Radiation Safety Officer (RSO) prior to the commencement of any TENORM work and the personnel using the instrumentation will be provided appropriate training.

Contamination meters/probes sensitive to alpha and beta contamination (e.g., a Geiger Mueller (GM) pancake type) will be used for routine contamination control activities.

Air emissions of long lived particulate radioactive material to the environment shall be monitored such that the individual member of the public likely to receive the highest dose will not be expected to receive a total effective dose equivalent in excess of 10 mrem (0.1 millisievert) per year from these emissions.

All instruments must be calibrated annually according to the manufacturer's specification and tested by check source prior to use.

Note: Use of an intrinsically safe survey meter is preferred but not required.

10. TENORM Surveys

10.1 TENORM Survey Requirements

Only personnel who are adequately trained in the hazards of TENORM and the performance testing and use of radiation monitoring equipment will conduct surveys for TENORM.

The testing equipment must be a radiation survey meter capable of operating in either rate meter or scalar mode with the ability to accurately measure gamma radiation dose rates in micro-Roentgen per hour ($\mu\text{R/hr}$) or equivalent and contamination levels in counts per minute (CPM). The survey meter must include both a gamma scintillation probe and pancake GM contamination probe.

Testing equipment must be calibrated annually according to the manufacturer's specifications. A copy of the current calibration documentation must be kept with the equipment. In addition to testing the equipment's regular calibration, the survey meter must be checked against a known source, verified to be in good operating condition, and have sufficient battery life before each survey to ensure the equipment is in proper working order.

All survey data should be recorded. Background levels must be established and documented before each survey to ensure monitoring results are comparable to previous surveys.

10.2 TENORM Gamma Radiation Surveys

Monitoring equipment that can detect gamma radiation must be used and the results should be recorded as a dose rate in $\mu\text{R/hr}$. As identified in the Plan of Operations, Section 5.3, a survey of the ground at the gate entrance will be performed monthly. A survey of various points along the perimeter and inbound roadways to the active cell will also be performed monthly. These surveys will be documented and retained for future reference.

If any elevated readings are found any place outside of the active cell, a complete grid survey will be performed and documented to establish the extent of any contamination or elevated readings. If there is any evidence that a reportable spill has occurred, the Facility Manager will make sure reporting to the DEQ occurs. A licensed radioactive material contractor would be called in to assist if needed.

Excavation of the impacted area will be performed with any material/soils extracted and carefully transported and placed within the active cell. A subsequent grid survey will be performed to verify the successful remediation. If elevated levels of radioactivity are still present, excavation, transport and disposal will continue until the final grid survey shows an absence of elevated readings above background. Clean soils, scoria or other suitable

Commented [OBM5]: Would also like to see roadways with in the facility. You also need to state if what you would do if contamination is found.

Commented [KR6R5]: Done.

Commented [OBM7]: Still needs to be addressed

Commented [KR8R7]: Should be good now. Of course, we can't fully survey all the roads every month. But staff does drive the site (including the perimeter) every day. This helps us stay on top of any incidents or perimeter penetration that might turn into a problem.

replacement material will be used to infill the excavated area as necessary. The initial survey and final post-remediation survey will be retained at the landfill for review by the DEQ.

Lead-210 has a low energy gamma ray and can only be reliably detected by conducting a surface contamination survey. Consult the Corporate RSO prior to conducting contamination surveys for Pb-210.

Dose rate measurements taken on the outside surfaces of suspected equipment shall be considered as potentially TENORM contaminated if the dose rate exceeds 2x background radiation levels.

Dose rate measurements should be taken within 1/2 inch of the equipment walls at locations where TENORM scale or sludge are suspected to build up (typically at the vessel's bottom).

Consideration should be given to equipment wall thickness and the distance the survey meter is from the suspected TENORM contamination.

10.3 TENORM Contamination Surveys

When surface dose or count rates measured on the equipment's outside surfaces exceed background levels, worker protection requirements must be specified for equipment handling, potential exposure to airborne particulates, and for vessel entry. This monitoring must be conducted by suitably qualified and trained personnel. Contamination surveys will be conducted on an as needed/as appropriate basis.

Monitoring and beta performing	Average**	5,000	equipment that can detect alpha radiation shall be used when these surveys.
	Maximum**	15,000	
	Removable	1,000	

Average surface contaminated equipment or PPE intended for release from restricted or controlled areas must meet the unrestricted release criteria of 5,000 dpm/100 cm² (0.83 Bq/cm²) averaged over 100 cm².

Equipment with removable contamination must be cleaned prior to release to levels less than 1,000 dpm/100 cm² (0.16 Bq/cm²) averaged over 100 cm².

Limits for the release of equipment or materials to unrestricted areas are provided in Table 3.

Table 3 – Alpha/Beat and or Gamma Release Limits (dpm per 100 cm²)

11. Regulatory

This practice is subject to the following regulatory requirements:

11.1 Federal

Wastes containing naturally occurring radioactive materials (TENORM) are generally not regulated by federal agencies. However, one area in which TENORM-containing wastes are regulated at the federal level is transportation.

TENORM-containing wastes that have a specific activity greater than 270 pCi/g (9.99 Bq/g) are subject to the U.S. Department of Transportation (DOT) regulations governing transport of radioactive materials. These regulations are contained in the Code of Federal Regulations, Title 49, Chapter 1, Part 173, Subpart I, "Class 7 (Radioactive) Materials," § 173.401 - 173.476.

11.1.1 North Dakota

TENORM-Specific Regulations:

Subject to the new TENORM rules as outlined in the North Dakota Administrative Code, Chapter 33.1-20-11, "Landfill Disposal of Technologically Enhanced Naturally Occurring Radioactive Material" as well as rules in Article 33.1-10-23, "Regulation and Licensing of Technologically Enhanced Naturally Occurring Radioactive Material."

11.1.2 Montana

TENORM-Specific Regulations:

Rules Passed in 2020: Montana Code Administration (MCA) 75-3-201. Also subject to the general radiation control regulations as outlined in the Administrative Rules of Montana, Title 37, Chapter 14, "Radiation Control."

11.1.3 Colorado

TENORM-Specific Regulations:

Rules passed in 2021 with enforcement as of July, 2022. Subject to the general radiation control regulations as outlined in 6 Colorado Code of Regulations, 1007-1, Rules and Regulations Pertaining to Radiation Control, Part 20 (TENORM), Part 3 "Licensing of Radioactive Material," and Part 4 "Standards for Protection against Radiation." CDPHE leverages their 2007 Guidance.

12. TENORM Waste Management

The management of TENORM wastes encompasses all aspects of initial characterization, handling, storage, transportation, processing, treatment, and disposal practices from the point of generation to the final disposition.

This practice provides recommendations based on the radiological properties of TENORM. In determining an acceptable material management option, other hazardous properties such as chemical toxicity must be considered. In some cases, the non-radiological hazardous properties of TENORM materials are the critical selection criteria for the preferred TENORM material management option. (See Waste Acceptance/Rejection in the Plan of Operations for details and SOPs.)

This practice outlines Unconditional Derived Release Limits (UDRL) for discrete TENORM wastes. All TENORM impacted materials above UDRL limits must be:

1. Rejected and returned to the generator with waste rejection notification generated to the DEQ, or
2. Rejected and transferred to a licensed facility such as our 13-Mile FST where it can generally be properly stored for subsequent transport and permanent disposal out of state at an approved disposal facility, or
3. Rejected and promptly transported and disposed of at a licensed facility out-of-state.

12.1 Discrete TENORM Sources

Labeling of TENORM Impacted Equipment

Impacted equipment should never be held outside of the landfill cell. However, if any equipment were identified at the facility that was not being disposed of immediately it should be identified as TENORM contaminated after surveying on the equipment's outside surfaces and tagged or labeled as:

This equipment may contain “Technologically Enhanced Naturally Occurring Radioactive Material – TENORM” – Avoid Breathing Dusts

Or use the following posting:



12.2 Sampling Procedures Relative to Worker Protection

The purpose of this sampling procedure is to provide a safe and documented standard for collecting and analyzing TENORM samples for analysis. The use of proper personal protective equipment (PPE) should be used while taking samples, to prevent inhalation or ingestion of TENORM contaminated materials. Specifically, the employee should minimally be wearing fire-resistant coveralls that are minimally changed or decontaminated at the end of each shift, safety glasses, and disposable gloves with the additional use of respirators as conditions dictate (or at the direction of the Landfill Manager or Corporate RSO).

A TENORM survey meter can be extremely helpful at the time of sampling in order to take a representative TENORM sample and to record the external radiation dosage levels of the sample. Specific to worker health, understanding the dose or exposure can help ascertain proper handling, storage, and PPE requirements.

In general, TENORM sampling should be conducted as part of an overall TENORM survey conducted by qualified personnel. This will ensure that subsequent analysis is meaningful and will provide the most value in regards to having an integrated approach for handling any potential TENORM contamination problems.

- TENORM samples must be put into strong plastic containers (i.e., Nalgene sample bottles) with screw-on lids. The lids should be sealed shut with duct tape after filling.
- All TENORM samples should be properly labeled with company name, location, contact name and phone number, description of contents, source dose rate and sample dose rate.
- A Warning label should be attached to the sample container which states the following: “Warning – Technologically Enhanced Naturally Occurring Radioactive Material” “Avoid Breathing Dust”

12.3 Transport of TENORM

The majority of transported oilfield TENORM contains radioactivity below 270 pCi/g (9.99 Bq/g) and is not subject to federal transportation regulations and accordingly falls under the jurisdiction of North Dakota state regulators. For transportation of higher level TENORM, consult the chart in 49 CFR 173.436 to verify that the concentration is safe for transport and that it has been properly labeled and packaged (and truck placarding as required).

Shipments of oilfield TENORM (Ra226, Ra228 and Pb210) with activity above 270 pCi/g (9.99 Bq/g) fall under the federal jurisdiction and are therefore subject to the requirements of federal regulations, including U.S. Department of Transportation (DOT) regulations. **All personnel are to obtain approval from the Corporate Radiation Safety Officer prior to shipping materials that falls under federal jurisdiction.**

TENORM waste coming into the Landfill should only be transported by a state licensed TENORM Transporter and should be properly manifested.

Equipment with TENORM should be appropriately contained to prevent the release of radioactive material during transportation. All openings where potential TENORM contamination could escape must be sealed prior to transport; heavy polyurethane and duct tape is usually sufficient.

The objective is to seal the TENORM contamination within equipment ensuring that there are no leaks or spills during the transport and unloading of the TENORM contaminated items. Tubing and piping should have pipe protectors installed or the ends sealed. The shipment should also be tarped to provide secondary containment and in case the ends get knocked off during loading or transport.

13. Emergency Response and Spills

13.1 Emergency Response

The first priority in spill or emergency response situations is to protect human life, ensuring that employees are attended to and their health and safety are secure. **TENORM does not pose a significant short-term health risk.** As a result, all emergency response plans must address immediate health and safety concerns as a first priority.

13.2 Environmental Control Measures

Spills at the Landfill would be a rare occurrence, however, being prepared for spill response where TENORM waste streams are concerned is still a worthwhile endeavor in protecting workers.

TENORM (solid) spills should be prevented as much as possible by using appropriate tarps and sealing pipe/equipment openings. If a spill occurs, the site must be secured and company personnel and regulatory authorities must be notified as appropriate. It is highly unlikely that a hydrovac or other tanker trailer with TENORM-impacted liquids or sludge would be at the Landfill. In the rare case of a liquid or sludge TENORM spill or inadvertent offload, a licensed TENORM Transporter that operates hydrovacs should be called to the site. Assuming the waste is not hazardous and can be classified as Special/E & P Exempt waste, the material should be evacuated, captured in the vehicle's tanks and taken to 13-Mile FST for offload at our licensed facility.

If safe to do so, all reasonable attempts should be made to control and contain the spill. Hazard assessment and implementation of safety controls must be implemented including establishment of control areas and documented site safety meetings.

TENORM related spills should be cleaned up by personnel trained in TENORM work procedures and under the supervision of the Landfill Manager or Corporate RSO. All appropriate safe work procedures and personal protective equipment must be worn as outlined in this TENORM code of practice.

Any containers and waste materials must be appropriately inventoried and labeled prior to being sent for TENORM storage or disposal. TENORM impacted areas will need to be confirmed cleaned through TENORM radiation surveys and/or radiological sampling.

14.0 Definitions

Activity (Radioactivity): The number of nuclear trans-formations that occur in a quantity of material per unit of time. Unit: Curie (Ci) = 3.7×10^{10} Becquerel (Bq), 1 Bq = 1 disintegration per second.

ALARA: A principle of risk management according to which exposures are kept as low as reasonably achievable, economic and social factors being taken into consideration. ALARA is a guiding principle of radiation protection.

Alpha Radiation (Alpha Decay): A high-energy positively charged particle ejected from the nucleus of an unstable (radioactive) atom, consisting of two protons and two neutrons. An alpha particle is a helium nucleus.

Annual Limit on Intake (ALI): The intake by inhalation, ingestion or through the skin of a given radionuclide in a year by a reference man which would result in a committed dose equal to the relevant dose limit. The ALI is expressed in units of activity.

Atomic Number: The number of protons contained in the nucleus of an atom. This number gives each atom its distinct chemical identity.

Atomic Mass (Mass Number): The total mass of protons and neutrons contained in the nucleus of an atom.

Background Radiation: The radiation to which an individual is exposed arising from natural radiation sources such as terrestrial radiation from radionuclides in the soil, cosmic radiation from space, and naturally occurring radionuclides deposited in the body from foods, etc.

Becquerel (Bq): An SI unit of radioactivity, equivalent to 1 nuclear transformation per second. Used as a measurement of the quantity of a radionuclide since the number of radioactive transformations (disintegrations) is directly proportional to the number of atoms of the radionuclide present. Replaces an earlier unit, the curie (Ci).

Beta Radiation (Beta Decay): The ejection of a high-energy negatively charged subatomic particle from the nucleus of an unstable atom. A beta particle is identical in mass and charge to an electron.

Contamination (Radioactive Contamination): Radioactive material present in excess of natural background quantities in a place it is not wanted.

Committed Dose: The total dose received from a radioactive substance in the body during the remainder of a person's life (assumed as 50 years for adults, 70 years for children) following the intake of the radionuclide.

Committed Dose: The total dose received from a radioactive substance in the body during the remainder of a person's life (assumed as 50 years for adults, 70 years for children) following the intake of the radionuclide.

Decay (Radioactive Decay): A process followed by an unstable nucleus to gain stability by the release of energy in the form of particles and/or electromagnetic radiation. NORM materials decay with the release of alpha particles, beta particles and/or gamma photons.

Decay Series (Radioactive Decay Series): A succession of radionuclides, each member of which transforms by radioactive decay into the next member until a stable nuclide results. The first member is called the "parent", the intermediate members are called "progeny" and the final stable member is called the "end product". In the two TENORM decay series; uranium-238 and thorium-232 are the "parents," and lead-206 and lead-208 are the "end products".

Derived Working Limit (DWL): A practical working limit derived from regulatory limits. Derived Working Limits can be compared to measured values at the work site to assess compliance with regulatory limits.

Diffuse TENORM: TENORM-contaminated material in which the radioactive concentration is uniformly dispersed. It is generally low in radioactive concentration, and relatively large in volume.

Discrete TENORM: TENORM-contaminated material in which radioactive substances are concentrated, or not uniformly dispersed throughout the material.

Dose Constraint: An upper bound on the annual dose that members of the public or incidentally exposed workers should receive from a planned operation or single source.

Dosimeter: A device for measuring a dose of radiation that is worn or carried by an individual

Equilibrium (Radioactive): In a radioactive decay series, the state that prevails when the rate at which progeny are produced is equal to the rate at which they are decaying. This form of equilibrium may be attained only if the precursor is very long-lived relative to any member of the decay chain. All members of a TENORM radioactive decay series in equilibrium have the same radioactivity.

Exclusion Zone: A work area where:

1. Access is limited to those persons who are required to work, or perform any duty in the area.
2. The boundaries of the area are clearly delineated and are made known to employees.
3. Any person entering the area has received appropriate instructions about the nature of the radiation hazards in the area.

Gamma Radiation (Gamma Rays or Gamma Photons): Electromagnetic radiation or photon energy emitted from an unstable nucleus in the process of ridding itself of excess energy. Highly penetrating, gamma rays lose energy as they pass through atoms of matter.

Half-life, Radioactive: The time required for a radioactive material to lose half of its activity through radio-active decay.

IAEA: International Atomic Energy Agency.

ICRP: International Commission on Radiological Protection.

Incidentally Exposed Workers: Employees whose regular duties are not expected to result in exposure to TENORM radiation. The public annual dose limit of 100 mrem (1 mSv) applies to this category of workers in an occupational exposure environment – the occupational domain.

NORM (Naturally Occurring Radioactive Materials): NORM is an acronym for naturally occurring radioactive materials comprising radioactive elements found in the environment. Long-lived radioactive elements of interest include uranium, thorium and potassium and any of their respective radioactive decay products such as radium and radon. Some of these elements have always been present in the earth's crust and within the tissues of all living beings. Although the concentration of NORM in most natural substances is low, higher concentrations may arise as the result of human activities. NORM is not regulated in the State of North Dakota. Please also review the TENORM definition in this section for additional, related information.

One-year Dosimetry Period: The period of one calendar year beginning on January 1 of the year following the year in which the Radiation Protection Management Program is started, and every period of one calendar year thereafter.

Occupationally Exposed Workers (TENORM Workers): Employees who expect to receive exposure to sources of TENORM radiation as a result of their regular duties. The

annual occupational dose **limit of 5000 mrem (50 mSv)** applies to this category of workers in an occupational exposure environment.

Commented [SDW9]: This should be 5000 mrem (50mSv) to maintain consistency.

Commented [KR10R9]: Sorry about that! We know better!

Personal Dosimetry Threshold: The annual effective dose above which radiation dosimetry of individual workers is required.

Radiochemical Analysis: Analysis of the radioactive content of a NORM sample. Radiochemical analysis will identify and quantify the concentration of various radionuclides in the TENORM sample.

Radionuclide or Radioisotope: A particular form of an element, characterized by a specific atomic mass and atomic number, whose atomic nucleus is unstable and decays or disintegrates with a statistical probability characterized by its physical half-life.

Radium-226: A radioactive element with a half-life of 1600 years. It is a particularly hazardous decay product of natural uranium, and is frequently the dominant TENORM nuclide. It decays into the radioactive gas Radon-222.

Radon: The only radioactive gas generated during natural radioactive decay processes. Two radioisotopes of radon are present – radon and thoron – each a decay product of radium. Radon (Rn-222) is found in the uranium decay series while thoron (Rn-220) is found in the thorium decay series.

Radon Progeny: The products of radon (radon-222) or thoron (radon-220) decay with short half-lives. Radon decay products include; Polonium-218 (RaA), Lead-214 (RaB), Bismuth-214 (RaC), and Polonium-214 (RaC'). Thoron decay products include; Polonium-216 (ThA), Lead-212 (ThB), Bismuth-212 (ThC), Polonium-212 (ThC'), and Thallium-208 (ThC'').

Rem: A historical unit of human dose equivalent. Rem is an acronym for roentgen equivalent man and was replaced in 1977 by the sievert in the international system of units.

Roentgen (R): The classical unit of radiation ionization in air, frequently misapplied as a unit of exposure in humans. Replaced in international system of units by the “coulomb per kg in air”.

Shielding: The reduction of radiation beam intensity by interposing, between the source and an object or person that might be exposed, a substance that absorbs

SI (International System of Units): The “metric” system of units generally based on the meter/kilogram/ second units. Special quantities for radiation include the Becquerel, gray and sievert.

Sievert (Sv): The sievert is the unit of radiation equivalent dose, H, that is used for radiation protection purposes, for engineering design criteria and for legal and administrative purposes. The sievert is the SI unit of absorbed radiation dose in living organisms modified by radiation type and tissue weighting factors. The unit of dose for the terms “equivalent dose” and “effective dose”. It replaces the classical radiation unit the rem. Multiples of sieverts (Sv) used in the Guidelines include millisieverts (mSv) and microsieverts (uSv).

Specific Activity (Radioactive Concentration): The number of Becquerel’s per unit of mass of a material. Units: Bq/g and kBq/kg.

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM): Naturally occurring radioactive material whose radionuclide concentrations are increased by or as a result of past or present human practices. TENORM does not include background radiation or the natural radioactivity of rocks or soils. TENORM does not include "source material" and "byproduct material" as both are defined in the Atomic Energy Act of 1954, as amended (AEA 42 USC §2011 et seq.) and relevant regulations implemented by the NRC.

Total Effective Dose Equivalent (TEDE): The sum of effective dose equivalent from external exposure and committed effective dose equivalent from internal exposure, thereby taking into account all known exposures.

15. References

American Petroleum Institute; “Bulletin on Management of Naturally Occurring Radioactive Materials (NORM) in Oil and Gas Production”, API Bulletin E2, (BUL E2), First Edition, April 1, 1992.

Baird, R.D. et al.: “Management and Disposal Alternatives for NORM Waste in Oil Production and Gas Plant Equipment,” API Report, RAE-8837/2-2, Rogers and Associates Engineers Corporation, Salt Lake City, UT (May 1990).

Grey, P.R.; “NORM Contamination in the Petroleum Industry”, Presented at the 16th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers, Dallas, Oct. 6-9, 1991.

International Basic Safety Standard for the Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No. 115, Vienna, 1996.

Radiation Protection and the Management of Radioactive Waste in the Oil and Gas Industry, IAEA Safety Reports Series No. 34, Vienna 2003

Waste Management Technical Committee, “Technical Report on the Management of Naturally Occurring Radioactive Material (NORM) in Waste”, July 2009

16. Appendices

Appendix A

State Contacts/Regulatory Agencies

North Dakota

Department of Environmental Quality
Radiation Control Program
4201 Normandy Street
Bismarck, ND 58503-1324
Phone: (701) 328-5166

Commented [OBM11]: Update number to 328-5166

Commented [KR12R11]: Done

Appendix A

ALARA Review

If a regulatory dose limit is exceeded, the following will be performed:

- immediate notification of the dose levels to the individual as well as to the North Dakota Department of Environmental Quality (DEQ);
- removal of the person from any work that is likely to add to the dose;
- assessment of the YTD dose received;
- conduct an investigation to determine the magnitude of the dose and to establish the causes of the exposure;
- identify and take any action required to prevent the occurrence of a similar incident; and
- immediately report the results of the investigation to the senior management and the Department of Environmental Quality.

Commented [OBM13]: Change to NDDEQ

Commented [KR14R13]: done

Appendix B

Notification to Female Workers

Name:	
Date of Notification:	

As required by OSHA and EPA, I have been informed in writing of:

- a) The risks associated with the exposure of embryos and unborn babies to radiation and the risks to breast fed infants from the intake of radioactive substances/material;
- b) The importance of informing the company (the licensee) as soon as feasible, in writing, should I become pregnant or be breast feeding;
- c) The rights of a pregnant worker and the rights of a breastfeeding worker; and
- d) The applicable effective and regulatory dose limits for a pregnant worker.

I acknowledge that I have received the above information:

Employee Signature

Date

Radiation Safety Officer

Date

Appendix C

Declaration of Pregnancy Form

Name:	
Date of Notification:	
Declaration Details:	

Declaration of Pregnancy

I, _____ (print full name), have read the United States Nuclear Regulatory Commission regulations and understand my rights. I have been advised on radiation risks to an embryo/fetus and on radiation protection measures. I am voluntarily declaring my pregnancy in writing with the understanding that I can withdraw this declaration at any time. I understand that the fetus/unborn baby exposure limit for the remainder of my pregnancy will be 500 mrem. To track this exposure, I will wear a fetal dosimetry badge for the remainder of my pregnancy.

My estimated date of conception: _____

Employee Signature

Date

Radiation Safety Officer

Date

Standard Operating Procedure

Air Sampling for Radionuclides SOP #1

1.0 Purpose:

This Standard Operating Procedure (SOP) describes the methodology that will be used by SECURE USA, LLC dba Secure Energy Services USA LLC (SECURE) to measure employee exposure to airborne radionuclides for all SECURE and contractor personnel who may be exposed to airborne radioactive materials above ambient local backgrounds in the course of any work activities performed on behalf of SECURE.

2.0 Scope:

This SOP may be applied, at the RSO's discretion, to any SECURE and contractor personnel whose work activities may reasonably be expected to result in potential exposure to airborne radioactive materials in excess of local ambient background values. Other personnel, at SECURE's option, may also receive airborne radioactivity evaluations in conformance to this standard operating procedure.

3.0 Equipment and Supplies:

Airborne radiation measurements are used to calculate potential internal exposure to radiation. Equipment and supplies for this evaluation may consist of any of the following:

- Alpha Track or other passive dosimeters for exposure to radon and radon daughters,
- Personal sampling pumps and suitable filters for evaluating exposure to airborne radioactivity (Ra-226 and Ra-228),
- Work area sampling pumps and suitable filters for evaluating general area exposure to airborne radioactivity, and
- Other exposure monitoring devices as specified by the SECURE radiation safety officer (RSO).

Commented [OBM15]: Need to add Ra-226 and Ra-228

Commented [KR16R15]: Done

Standard Operating Procedure

Dose Evaluations SOP #2

1.0 Purpose:

This SOP describes the methodology that will be used by SECURE to evaluate and record the radiation dose received by all SECURE and contractor personnel who may be exposed to radioactive materials or radiation above ambient local backgrounds in the course of any work activities performed on behalf of SECURE.

2.0 Scope:

This SOP applies to all SECURE and contractor personnel whose work activities may reasonably be expected to result in potential exposure to radioactive materials or radiation in excess of local ambient background values. Other personnel, at SECURE, option, may also receive dose evaluations in conformance to this standard operating procedure.

3.0 Equipment and Supplies:

Dose evaluations will consider both internal and external exposures. Equipment and supplies for this evaluation may consist of any of the following:

- Thermoluminescent (TLD) or Optically Stimulated Luminescence (OSL) dosimeters for measuring external radiation exposure (personal or area as applicable);
- Alpha Track (or other passive dosimeters) and air sampling as may be necessary to assess exposure to radon and/or radon progeny;
- Personal sampling pumps and suitable filters for evaluating exposure to airborne radioactivity;
- Work area sampling pumps and suitable filters for evaluating general area exposure to airborne radioactivity; and
- Other exposure monitoring devices as specified by the SECURE radiation safety officer (RSO).

4.0 Special Conditions or Requirements

In the event that special radiation exposure hazards may exist for a specific project or work activity, the RSO may specify additional exposure monitoring or calculation procedures beyond those specified in this standard operating procedure (SOP).

5.0 Procedure

Workers at the landfill will be limited to potential exposure to naturally occurring radioactive materials derived from oil and gas production wastes and other similar activities. As such, the likely exposure scenarios are limited to whole-body exposure to elevated gamma radiation fields and internal exposure by way of inhalation of dust containing radioactive materials. Elevated radon and radon daughter concentrations as a result of the decay of naturally occurring radioactive materials may also be a possible route of exposure.

This SOP addresses these possible exposure routes. If other project activities present additional exposure routes, this SOP will be amended or supplemented by additional material to address other exposure pathways.

5.1 External Exposure to Ionizing Radiation

External exposure to ionizing radiation will be measured using a program of external dosimetry. Each SECURE employee whose regular work activities may lead to exposure to external radiation in excess of local ambient background will be issued a thermoluminescent (or OSL) dosimeter provided through a qualified vendor of dosimetry service. These dosimeters will be evaluated on a schedule determined by the RSO based on reasonably anticipated exposure rates. Dosimeters, results of air sampling programs (and bioassay if applicable) will be evaluated at least quarterly, and more frequently if anticipated doses may be in excess of 10% of any annual exposure limit (e.g., 5000 mrem, 2000 DAC hrs, one ALI per year).

Dosimetry results will be recorded for each potentially exposed worker. Dosimetry results will be provided to employees as they are received. The SECURE Corporate RSO or health physicist will be available to explain the meaning and significance of these exposure results to employees.

5.2. Internal Exposure to Ionizing Radiation

Any internal exposure to ionizing radiation for SECURE and contractor employees would come through inhalation of radon and radon progeny and inhalation of airborne particulates containing radioactive materials. At outdoor sites or facilities, radon and progeny exposure will be considered negligible unless data or specific site considerations dictate otherwise.

If the radiation hazard indicates the likelihood of measurable radon or radon daughter exposure above the expected range of background, Alpha Track, other acceptable passive radon monitoring devices, and/or Kusnetz method-based air sampling programs will be used and results will be included in the overall dose assessment for all site or project personnel.

Other internal exposures, principally through inhalation of airborne particulates containing radionuclides, may be evaluated through a regular program of personal and work area air monitoring. This program is described in SOP #1. The results of the personal and work area exposure monitoring program will be used to calculate a committed effective dose equivalent (CEDE) value based on the concentrations of specific radionuclides detected in the airborne particulates, in combination with exposure time and other factors effecting intake, (e.g., breathing rates, respiratory protection factors, etc.).

The value of the CEDE will be calculated using Derived Air Concentrations (DAC) and /or Annual Limits on Intake (ALIs) for the applicable solubility classes (D,W,Y) from the United States Nuclear Regulatory Commission (USNRC) in 10CFR20, Appendix B (or F,S,M absorption types in subsequent ICRP guidance). If the solubility class of the nuclide compound is unknown, the most insoluble category (Y or S) will be used (except for natural or low enriched uranium where chemotoxicity may be limiting – see intake limits for soluble uranium in 10CFR20).

CEDE values for each employee will be calculated at least quarterly, and more frequently at the discretion of the RSO. CEDE values will be incorporated in each employee's total equivalent dose exposure (TEDE) on a quarterly basis or *pro rata* in the event of termination regardless of reason in advance of a calendar quarter.

External dose (Dose Equivalent = DE), CEDE, and TEDE values will be presented to each employee on a quarterly basis or upon termination regardless of reason. The meaning and significance of the individual components of the TEDE and the method of calculation will be

provided to each employee on request, and will be provided to future employers as part of the individual's lifetime exposure record.

In the event that an individual airborne radiation exposure sample indicates that an employee may have been exposed to airborne radioactivity in excess of 25% of the applicable derived air concentration (DAC), bioassay sampling (e.g., urinalysis) will be required. The affected employee will be notified as soon as practicable. Upon receipt of laboratory analytical results, verification of bioassay results and of intake and performance of calculations of employee's actual exposure, if necessary, these results will be transmitted to the employee together with any additional explanatory material that may be appropriate.

6.0 Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) of the dosimetry program will be ensured by using vendors who are certified through the National Voluntary Laboratory Assessment Program (NVLAP). Dosimetry vendors must submit NVLAP certification as a condition for use as a vendor to SECURE.

Laboratory analysis of air samples will only be performed by organizations with a recognized radiological quality control system (e.g., per NELAP). The SECURE RSO will evaluate potential vendors of laboratory radiological monitoring services to determine the acceptability of their internal QA/QC system.

As part of the annual ALARA and license compliance audit to be performed by the RSO, the dose evaluation program will be reviewed. A written report to SECURE management will be performed as a result of this audit presenting findings, shortcomings, and recommendations for future action.

TEDE calculations will be subject to external audit upon request by the client, competent oversight agency, individual employee, or SECURE management. All data and calculations used to determine the TEDE will be subject to this audit and oversight.

7.0 Documentation

Exposure records will be maintained for each employee. Records will include the results of individual dosimetry, individual airborne exposure monitoring, bioassay results and other exposure monitoring results assigned to the employee by proximity or similar work activities. All individual dose calculations will be included in the employee's record.

In addition to individual employee exposure records, overall records of the dose assessment activity will be retained by SECURE, including all vendor assessments, performance reviews, air sampling records, original laboratory data from individual or work area samples including bioassay results generated during the project.